Distribution and Grid Modernization Planning to Accelerate Deployment of Distributed Energy Resources

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Types of distribution system plans

Electric utility distribution-related plans that include distributed energy resources (DERs), categorized from narrow to wider scopes:

- **Transmission and distribution (T&D) improvement plan** - Request expedited cost recovery for certain electricity system improvements (e.g., IN infrastructure Improvement Charge for T&D and storage investments)
- **DER plan** - Evaluates benefits and costs of DERs, assesses ways to increase their cost-effective deployment, and facilitates improved integration of DERs in distribution systems (e.g., NV)
- **Grid modernization plan -** Presents a reasoned strategy that links a proposed technology deployment roadmap to stated objectives; may include requests for regulatory approval of grid modernization investments and programs (e.g., NM)
- **Integrated distribution system plan** (IDSP, or integrated grid plan)* - Provides a systematic approach to satisfy customer service expectations and state's grid planning and design objectives, including integration and utilization of DERs and grid modernization (many states); may coordinate planning across T&D systems or bulk power and distribution systems more broadly (e.g., HI)

Transmission, electrification, energy security, and DSM plans may inform distribution and grid modernization plans.

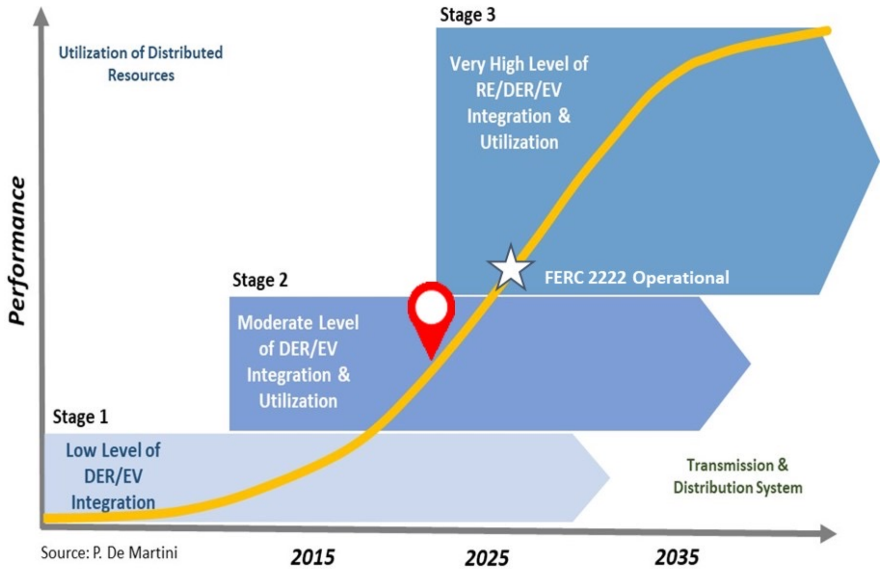
*See key IDSP process elements and proposed technology roadmap in *Extra Slides.*

Distribution system evolution based on DER adoption

Stage 1: *Low DER adoption (<5% of peak*).* DER levels can be accommodated within existing distribution systems without material changes to infrastructure, planning and operations. Grid modernization addresses reliability, resilience, safety, and operational efficiency and enabling DER integration and utilization at low levels.

Stage 2: *Moderate adoption of DERs (5-20% of peak) including for wholesale & distribution services.* DERs — individually and in aggregations — are increasingly used as load-modifying resources for both distribution non-wires alternatives (NWAs) and wholesale capacity and ancillary services. Integrated distribution system planning and grid modernization are needed to enable real-time observability and operational use of DERs.

Stage 3: *Large-scale adoption of DERs (>20% of peak), including for wholesale & distribution services, plus community microgrids.* Utilization of DER aggregations (virtual power plants) is optimized to support grid service requirements for distribution and transmission systems. Multi-use/community microgrids help support local energy supply and resilience. Ultimately, distribution system-level energy transactions are enabled. This stage of DER utilization requires coordination across jurisdictions (e.g., FERC Order 2222) and infrastructure to support both grid and market operations.



*Installed DER capacity as a percent of distribution system peak

Source: Paul De Martini, Newport Consulting

Proactive planning is more effective.

Tell utility customers where the grid needs help and what services the grid needs. Provide appropriate incentives.

- *DER forecasting* helps planners avoid overbuilding and feeds into analysis of which feeders may be stressed by DERs.
- *Hosting capacity* is the amount of DERs that can be interconnected without adversely impacting power quality or reliability under existing control and protection systems and without infrastructure upgrades.

Together, these processes identify feeders that are likely to see DER growth and can be considered for proactive upgrades.

- *Non-wires alternatives* are DERs that provide specific services at specific locations to defer some traditional infrastructure investments, leveraging customer and third-party capital.
- *Locational net benefits analysis* systematically analyzes DER costs and benefits to assess the net benefits DERs can provide for a given area of the distribution system.

These analyses can inform retail rates and tariffs — e.g., location-based incentives for geotargeted DERs.*

*See *Extra Slides* for more on locational net benefits analysis and an example tariff.

Source: Adapted from Debbie Lew, Emerging distribution planning analyses, 2020

State trends for accelerating DER deployment through distribution and grid modernization planning

- More states are establishing planning requirements for DERs, distribution systems and grid modernization, by legislation or regulation.
  - Including planning to accelerate grid modernization and DER deployment
- Common state objectives for distribution & grid modernization planning involve DERs:
  - Support DER integration and utilization for grid services
  - Increase customer choice and engagement in energy services
  - Reduce greenhouse gas emissions and support a clean energy transition
  - Improve grid resilience
  - Accelerate deployment of new technologies and services to optimize grid performance and minimize electricity system costs
- State requirements that can accelerate DER deployment include:
  - DER-related analyses (*next two slides*)
  - Planning across bulk power and distribution systems (e.g., see Hawaiian Electric's draft 2023 Integrated Grid Plan)
  - Alignment of integrated resource planning (IRP) and distribution system planning, including DER forecasts (e.g., MN 12/8/22 order in Docket No. 21-694)
  - Integration of electrification planning with DER planning or distribution planning (e.g., NV and MN)
  - Expedited cost recovery* for grid modernization investments to support higher DER deployment levels (e.g., NM, IL, MN, IN)

*Utility consumer advocates and other stakeholders may not favor this approach.

DER-related distribution planning elements (1)

- DER forecast
  - Types, sizes, amounts and locations
- Hosting capacity analysis*
  - Utility maps show where interconnection costs will be low or high; supporting data provides details
  - Used for DER development, interconnection screens and distribution planning
- Grid needs assessment and NWA analysis to identify:
  - Existing and anticipated capacity deficiencies and constraints
  - Traditional utility mitigation projects
  - A subset of these planned projects that may be suitable for NWA to defer or avoid infrastructure upgrades for load relief, voltage, reducing power interruptions, and improving resilience

*See example state requirements and use cases in *Extra Slides*.

DER-related distribution planning elements (2)

- Programs to geotarget energy efficiency, demand flexibility, distributed PV and storage, and managed electric vehicle (EV) charging to meet location- and time-dependent distribution system needs
- Grid modernization strategy and technology roadmap
  - Including investments needed to integrate, monitor and use DERs for grid services
- Proposals for pilots
  - Resilience projects (e.g., solar+storage, microgrids)
  - Time-varying pricing (e.g., EVs)

Figure 8. Measures creating the total demand reduction for the pilot

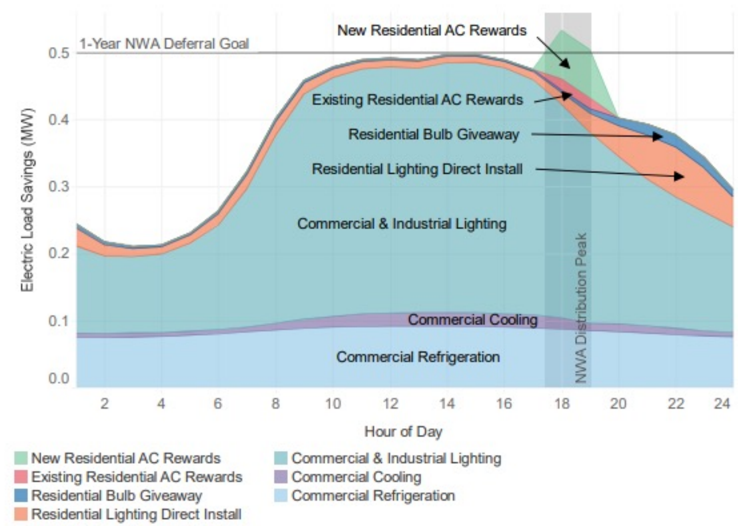
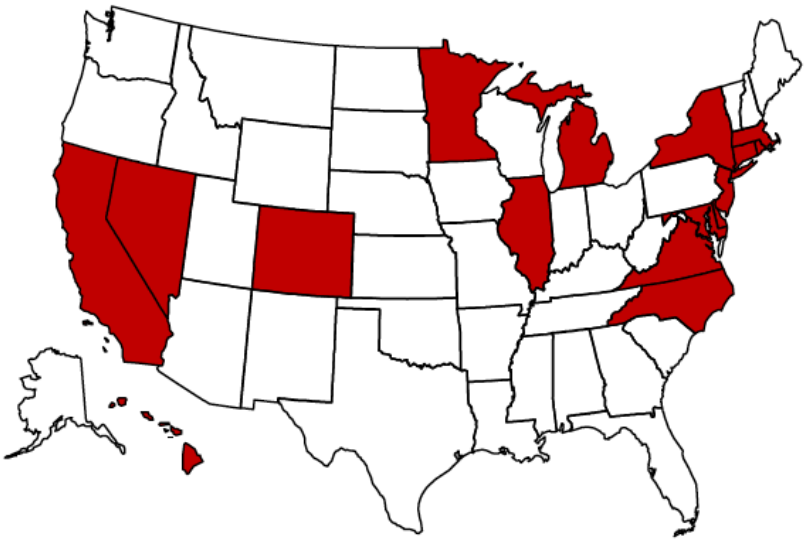


Figure source: CEE 2021

Hosting capacity analysis filed in 16 states + DC*



*Source: Interstate Renewable Energy Council, presentation for New Mexico Public Regulatory Commission. May not be fully comprehensive.

Example hosting capacity maps

Southern California Edison
Orange & Rockland – NY, NJ
Xcel Energy – MN
Dominion Energy – VA, NC
Pepco Holdings – DC, MD, DE, NJ
Unitil – MA
National Grid – RI
National Grid – MA
Eversource – CT
NY: Central Hudson, Consolidated Edison, National Grid, Rochester Gas and Electric, New York State Electric and Gas

Source: https://www.irecusa.org/our-work/hosting-capacity-analysis/

California “Integration Capacity Analysis”

- Models how much new distributed generation — as well as **load** (including EV charging) — can be accommodated on the distribution system at specific locations, using actual grid conditions
  - Understanding capacity for new load is especially important in the context of state electrification initiatives, as well as energy storage projects (load+generation).
- PUC’s ruling on Jan. 27, 2021, directed utilities to refine Integration Capacity Analysis maps and include them in data portals: PG&E, SCE (see user guide), SDG&E*

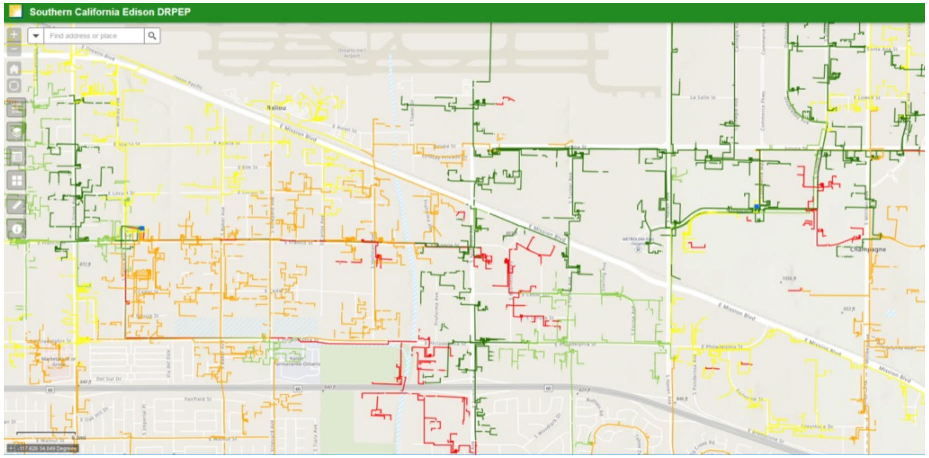
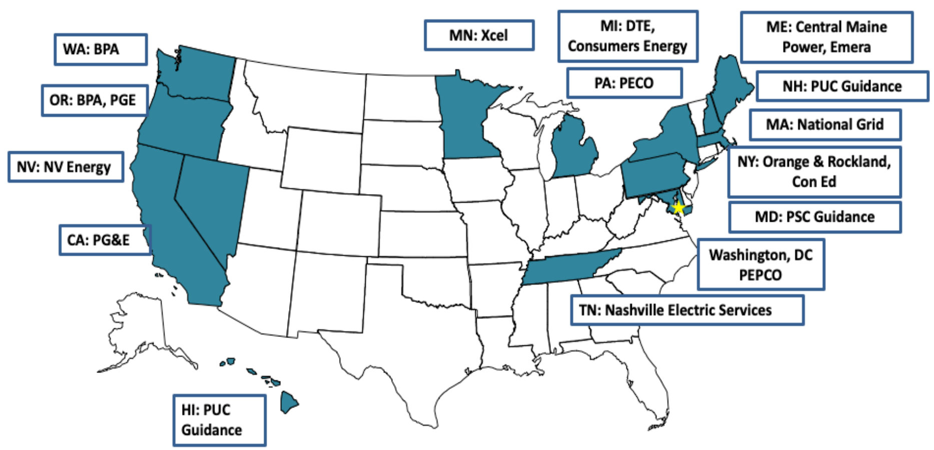


Figure source: Southern California Edison

*In addition to maps, the data portals include the utility’s Distribution Investment Deferral Framework map (Grid Needs Assessment + Distribution Deferral Opportunity Report).

Non-wires alternatives

- Objectives: Provide load relief, address voltage issues, reduce power interruptions, enhance resilience, or meet local generation needs
- Potential to reduce utility costs
  - Defer or avoid infrastructure upgrades
  - Implement solutions *incrementally,* offering a flexible approach to uncertainty in load growth and potentially avoiding large upfront costs for load that may not show up.
- Typically, the utility issues a competitive solicitation for NWA for specific distribution system needs and compares these bids to the utility's planned traditional grid investment to determine the lowest reasonable cost solution.
- Jurisdictions that require NWA consideration include CA, CO, DE, DC, HI, ME, MI, MN, NV, NH, NY and RI. Other states have related proceedings, pilots or studies underway.

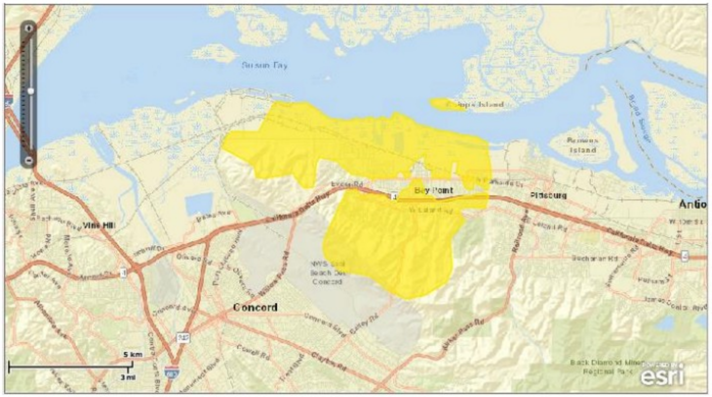


Case studies featured in [Locational Value of Distributed Energy Resources]

NWA procurement strategies: California example

- 3 procurement mechanisms identify opportunities to cost-effectively defer or avoid traditional utility investments to use DERs to mitigate forecasted deficiencies:
  1. Distribution Investment Deferral Framework - Annual Grid Needs Assessments and Distribution Deferral Opportunity Reports
     - Examples: SCE, PG&E, SDG&E
     - Following a Distribution Planning Advisory Group stakeholder process, the utilities submit Advice Letters to the CPUC seeking approval to issue request for offers (RFO) for competitive annual solicitations for specific deferral projects.
  2. Standard Offer Contract Pilot* - Utilities select offers for front-of-the-meter* DERs through a simple auction with *standardized contract terms*.
  3. Partnership Pilot – Utilities *prescreen aggregators* to procure behind-the-meter (BTM)* DERs to accelerate deferral implementation; *first-come, first-served*

Willow Pass Substation Bank 3 Map

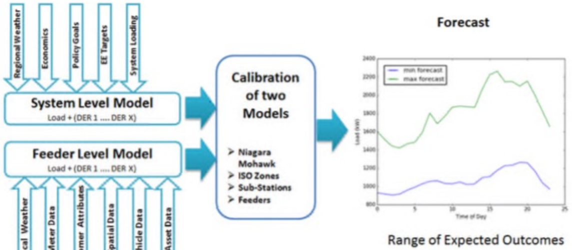


Source: PG&E presentation on 2021 RFO

*See *Extra Slides* for more information on these programs. Front-of-the-meter refers to assets directly connected to the distribution network. BTM refers to DERs connected to the customer's side of the utility's service meter.

Source: Adapted from Natalie Mims Frick, Berkeley Lab

Example planning challenges (1)



Source: National Grid

- Forecasting DERs and impacts for specific distribution system components/areas
  - Making DER forecasts spatially granular (e.g., by substation, feeder)
  - Incorporating DER program shapes
  - Incorporating EV forecasts
  - Disaggregating load forecasts to identify trends in individual end uses and assess DER impacts on load profiles
  - ➢ *Among the solutions: using end-use load profiles; using customer adoption models to account for the impact of DER cost and performance, incentives, retail rates, peer effects, and customer demographics; benchmarking against 3rd party forecasts; probabilistic forecasting; and using scenarios (e.g., electrification, high PV+storage)*
- Hosting capacity analysis
  - Costs (hardware, software, personnel)
    - For validating data inputs, improvements for modeling feeders, simulating power flows, and providing results
  - Accuracy
    - Data availability, validation, granularity (sub-feeder), model settings, update frequency (annually insufficient)
  - Typically only PV is included, not other DERs — energy efficiency and demand flexibility can *increase* hosting capacity
  - Electrification usually not considered — except CA, MN requires consideration of EV charging
  - Data redaction due to utility concerns about cyber/physical security — whether a bad actor can use information about line location, loads, or lines supplying critical facilities for targeted attacks
  - ➢ *But, locational data are available from other sources (e.g., Google Maps), and data alone is insufficient to carry out an attack and may not increase the risk of a successful attack.**

*Interstate Renewable Energy Council, Key Decisions for Hosting Capacity Analysis, 2021

Example planning challenges (2)

- Consideration of proactive upgrades to increase hosting capacity
  - Cost allocation
- Non-wires alternatives
  - Insufficient quantity of viable bids to meet the utility's full need for any deferral opportunities
  - Long lead times for procurement
    - New CA Standard Offer Contract and Partnership Pilot are designed to accelerate procurement timelines to enable NWA deployment.
  - Often NWA don't pass cost-benefit test. Few DERs selected to date, but…
    - Examples of successful NWA projects in NY, CA, MI and MN*
    - Xcel Energy proposed changes to its NWA process for MN with stakeholder input.

*Schwartz and Frick 2022, Frick et al. 2021, DTE 2021, PG&E 2022 and CEE 2021

Source: Con Edison BQDM Quarterly report, May 2022

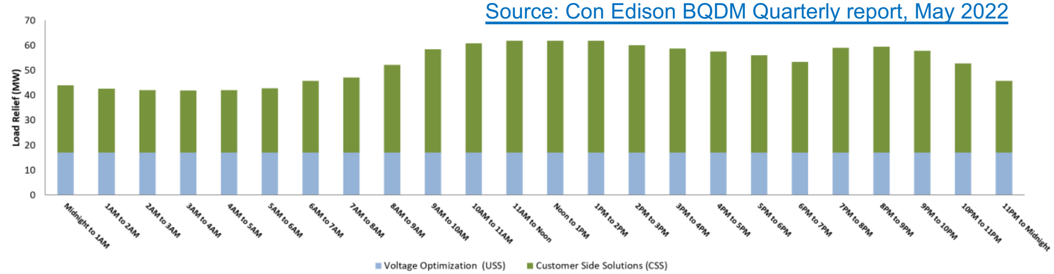


Figure 1: Hourly Load Profile of Operational BQDM Customer-Side Solutions and Non-Traditional Utility-Side Solutions. *Note: A 1.5 MW 4-hour utility-side battery energy storage system is not depicted in the load profile as its dispatch varies.*

Aspect/Component	Current Method	Proposed Method
Timeframe	Full NWA lifetime	**10-year deferral period***
Ownership Model	Utility ownership	**Load reduction contract or** utility ownership
Load Reduction Requirement	Exact MWh of load at risk on peak day	**Peak output for the duration of the risk**
Stacked Values	No stacked values	**Stacked values included**
Pro-Rating Values	No pro-rating, full values included	**Values pro-rated** for just the load reduction period (ARR split)
Solar Performance	PVWatts TMY simulation for one location in Minnesota	PVWatts TMY simulation for **five locations** in Minnesota

* Subject to change.

Source: Jody Londo, Integrated Distribution Planning at Northern States Power Company — Minnesota. May 13, 2022.

Catalog of State Distribution Planning Requirements

- *Later this spring* – Interactive map, detailed state-by-state table, document library
- *Later this year* — Report updating our 2017 and 2018 publications on state engagement in distribution system planning as well as presentations on regulatory approaches
  - Materials will be posted on Berkeley Lab's integrated distribution system planning website
- **General information and procedural requirements**
  - Planning goals and objectives, type of plan (e.g., grid mod plan, distribution system plan, integrated grid plan, DER plan, T&D improvement plan), frequency of filing, planning horizon, term of action plan, stakeholder engagement & equity, type of commission action on filed utility plans
  - Links to legislation & regulations, commission proceedings & orders, utility plans
- **Substantive requirements**
  - Baseline information required on current distribution system
  - Load and DER forecasting
  - Reliability and resilience analysis and metrics
  - Grid needs assessment & solution identification, including NWA analysis
  - Hosting capacity analysis
  - Grid modernization strategy and roadmap
  - Coordination with other types of planning

Also: **Berkeley Lab/NASEO brief on ways state energy offices are engaging in distribution planning**

Resources for more information

Berkeley Lab's integrated distribution system planning website

Berkeley Lab's research on time- and locational-sensitive value of DERs

Center for Energy and Environment (CEE), Non-Wires Alternatives as a Path to Local Clean Energy: Results of a Minnesota Pilot, 2021

DTE Electric Company, 2021 Distribution Grid Plan: Final Report, Michigan Public Service Commission Case No. U-20147, 2021

N. Frick, S. Price, L. Schwartz, N. Hanus and B. Shapiro, Locational Value of Distributed Energy Resources, Berkeley Lab, 2021

ICF, Integrated Distribution Planning: Utility Practices in Hosting Capacity Analysis and Locational Value Assessment, 2018

NARUC, Berkeley Lab, and Pacific Northwest National Lab, Peer-Sharing Webinars for Public Utility Commissions on Integrated Distribution System Planning, 2023

L. Schwartz and N. M. Frick, Berkeley Lab, "State regulatory approaches for distribution planning," Presentation for New England Conference of Public Utility Commissioners," June 16, 2022

B. Sigrin and A. Mills, "Forecasting load on distribution systems with distributed energy resources," Distribution Systems and Planning Training for Southeast Region, March 11, 2020

Pacific Gas & Electric, 2022 Grid Needs Assessment, California Public Utilities Commission proceeding R.21-06-017, Rulemaking to Modernize the Electric Grid for a High Distributed Energy Resources Future, August 15, 2022

U.S. Department of Energy, *Modern Distribution Grid*, Vol. IV, 2021

Xcel Energy, *2022-2031 Integrated Distribution Plan*, 2021

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For more information

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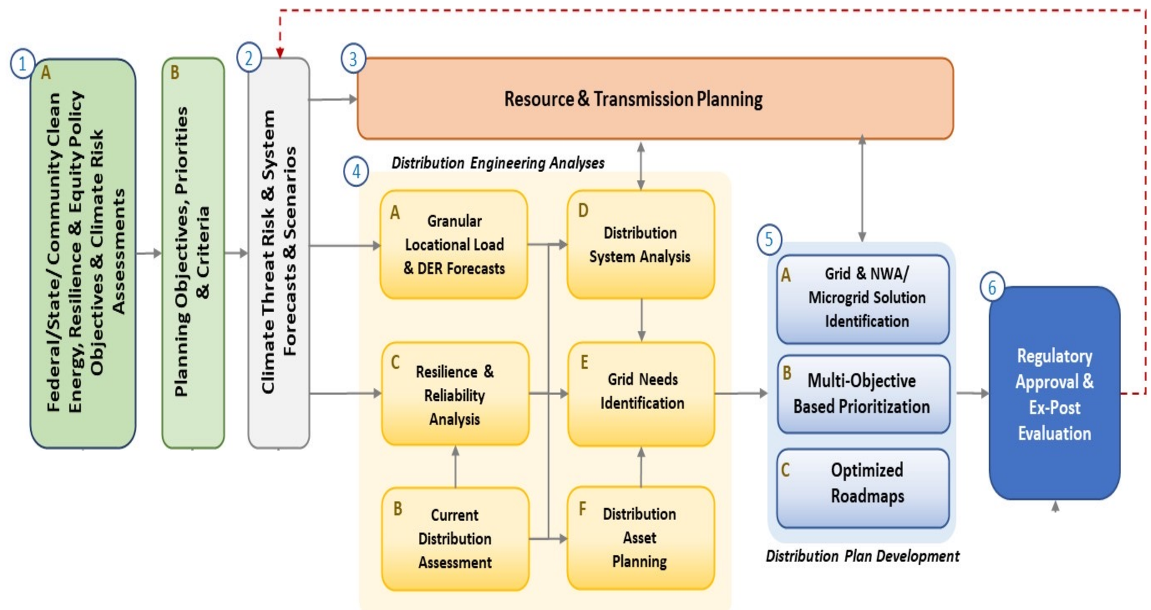
Extra Slides

Key process elements for IDSP

1. Planning Objectives, Priorities and Criteria
2. Forecasting
   - System Forecasts & Scenarios
   - Risks from Climate Threats
3. Resource & Transmission Planning*
4. Distribution Engineering Analyses
5. Solution Identification, Evaluation and Prioritization
6. Regulatory Review & Ex Post Evaluation



Stakeholder engagement throughout

*Integration with IRP and transmission planning where applicable

Source: Paul De Martini, Newport Consulting

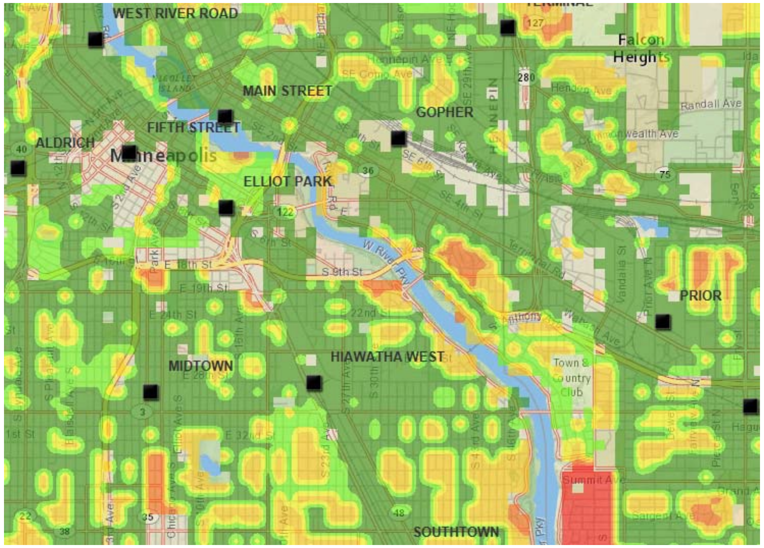
Hosting capacity analysis use cases

	Use Case	Objective	Capability	Challenges
Hosting Capacity Analysis Use Cases	**Development Guide**	Support market-driven DER deployment	Identify areas with potentially lower interconnection costs	Security concerns; analysis/model refresh; data accuracy and availability
	Technical Screens	Improve the interconnection screening process	Augment or replace rules of thumb; determine need for detailed study	Data granularity; benchmarking and validation to detailed studies
	Distribution Planning Tool	Enable greater DER integration	Identify potential future constraints and proactive upgrades	Higher input data requirements; granular load and DER forecasts

Source: ICF International

Example hosting capacity analysis requirements over time: Minnesota (1)

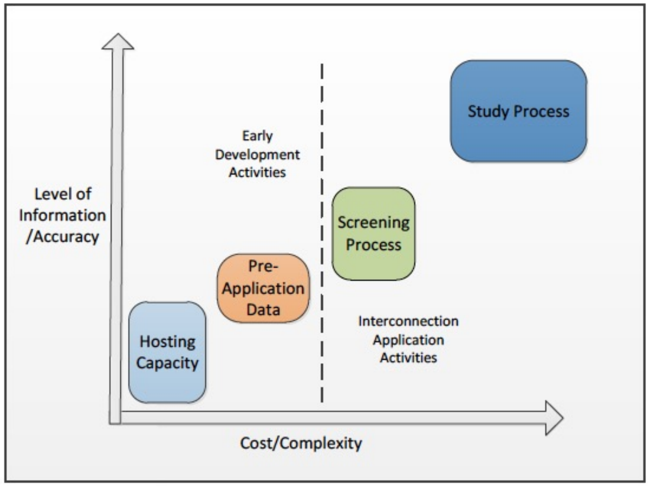
- The PUC requires analysis of each feeder for solar ≤1 MW and potential distribution upgrades necessary to support expected distributed generation levels, based on utility's IRP filings and Community Solar Gardens program.
- Utility filed 1st hosting capacity analysis in 2016 (Docket 15-962)
  - Commission's Aug. 1, 2017 decision requires filing analysis Nov. 1 each year
  - Provided guidance for future analysis, including reliable estimates and maps of available hosting capacity at feeder level
    - Details to inform distribution planning and upgrades for efficient integration of distributed generation
    - Detailed information on data, modeling assumptions and methodologies



Source: Xcel Energy

Example hosting capacity analysis requirements over time: Minnesota (2)

- Aug. 15, 2019, order (Docket 18-684) required further improvements
  - Work with stakeholders to improve value of analysis, with more detailed data in maps
  - Provide spreadsheet with hosting capacity data by substation and feeder, with peak load, daytime minimum load, installed generation capacity, and queued generation capacity
  - For feeders with no hosting capacity, identify “The full range of mitigation options … including a range of potential costs … and financial benefits….” Some solutions are low or no cost.
  - Identify costs and benefits of replacing or augmenting initial interconnection review screens and supplemental review and automating interconnection studies
- July 23, 2020, order (Docket 19-666)
  - Adopts long-term goal to use hosting capacity analysis in interconnection fast-track screens
  - Requires estimating costs for more frequent updates and other use cases (e.g., initial interconnection review screens and supplemental review), considering *load* hosting analysis
- June 1, 2022, order (Docket M-21-694)
  - Modified future requirements to proactively plan investments in hosting capacity and other necessary system capacity to allow distributed generation and EV additions consistent with the utility’s forecast for DERs — in coordination with IRP

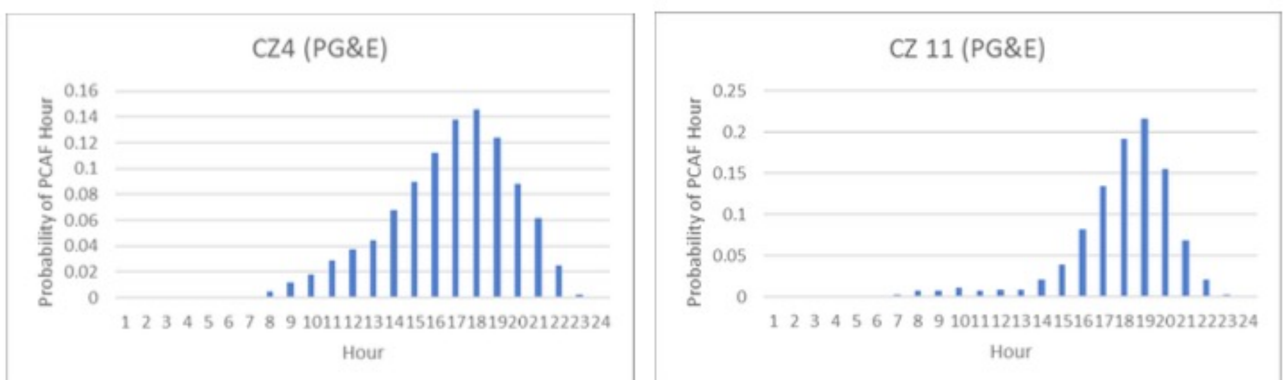


Source: Xcel Energy 2021

Locational value of DERs

- In addition to analyzing DERs as alternatives to *specific projects*, utilities can conduct *systematic* studies of DER locational value to:
  - Better understand where to target them
  - Calibrate incentive levels
  - Reduce load growth for specific areas of the distribution system
  - Reduce the need for traditional distribution system upgrades
- Locational net benefits analysis analyzes costs and benefits of DERs to determine the net benefits they can provide for a given area of the distribution system.
- These studies can become a routine and transparent part of the distribution planning process. The information also can be used for DER programs and rate designs.

Example PG&E peak capacity allocation factors distribution by hour for climate zone 4 and climate zone 11. Source: [Avoided Cost Calculator]() (2021)



DER tariffs

- ► DER payments based on DER value
  - ■ For example, New York's [Value Stack tariff] compensates DER based on location, in addition to energy, capacity, environmental and demand reduction values
  - ■ Each utility identifies locational-specific relief value zones
  - ■ Response to event calls in these zones results in additional DER compensation

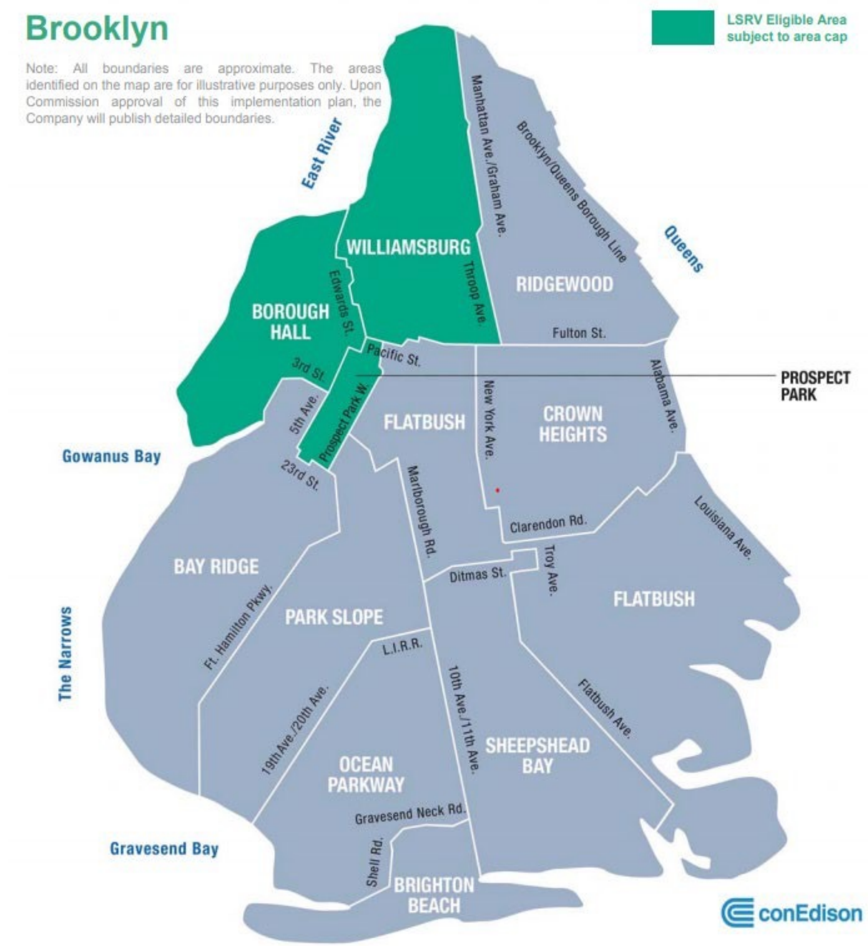
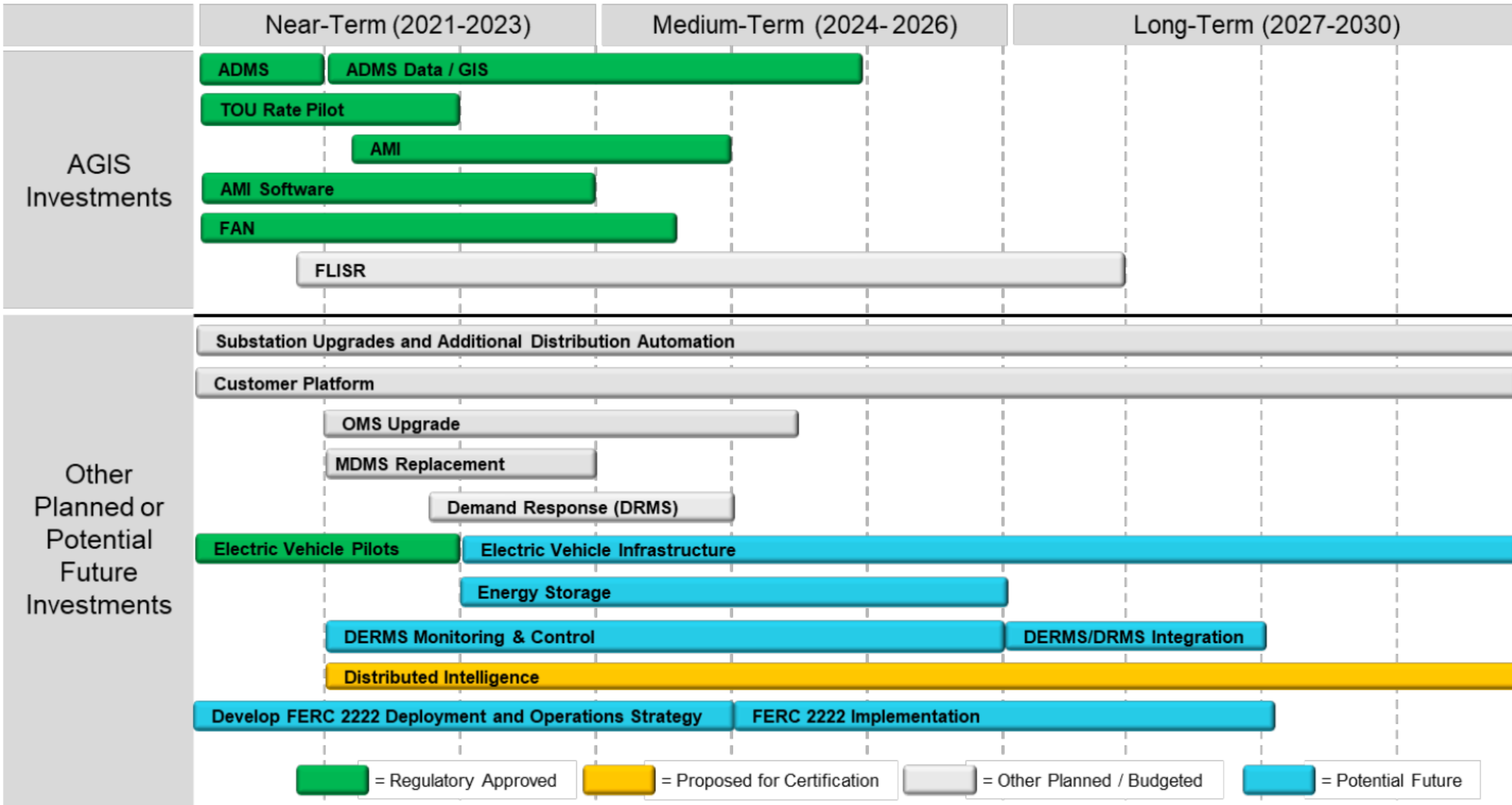


Figure source: Con Edison LSRV Zone map

Source: Adapted from Juliet Homer, Pacific Northwest National Laboratory

Illustrative Grid Modernization Investment Plan



Source: Xcel Energy 2021

AGIS – Xcel Energy's Advanced Grid Intelligence and Security initiative, ADMS – Advanced Distribution Management System, GIS – Geographic Information System, AMI – Advanced Metering Infrastructure, FAN – Field Area Network (visibility and control), FLISR - Fault Location, Isolation, and Service Restoration, OMS – Outage Management System, MDMS – Meter Data Management System, DERMS – DER Management System

Partnership Pilot

- Customers participate in the pilot through a pre-screened aggregator.
- Pre-screened aggregators meet experience and financial viability criteria, and have demonstrated the capability to reliably dispatch DERs.
- The pilot is first-come, first-serve. It remains open until the subscription period closes or when the utility contracts 120% of identified need.
- When the utility receives offers that meet 90% of the capacity needed to defer the distribution project, the utility contracts with the aggregators.
- The pilot budget is capped at 85% of the estimated cost per kW of traditional investment.
- Annually, each utility must identify three projects to test the pilot.

Southern California Edison Partnership Pilot Project

Partnership Pilot Project Name: New Circuit at El Casco Substation

Project Cities May Include	Need Area	Tranche	Tranche Status	Tranche Procurement Goal (Capacity - MW)	Tranche Procurement Goal (Energy - MWh)	Subscription Period Launch Date	Subscription Period End Date	Operating Date	Deferral Value (Cost Cap-PV $)	Tariff Budget (Nominal $)	Deployment Budget	Reservation Budget	Performance Budget
Beaumont, Calimesa	Jonagold Circuit	1	Open	0.1	0.1	1/18/2022	12/1/2022	6/1/2024	$65,627	$12,130	$2,426	$3,639	$6,065
		2	Closed	0.3	0.6	~1/15/2023	12/1/2023	6/1/2025	$61,271	$80,056	$16,011	$24,017	$40,028
		3	Closed	0.4	0.7	~1/15/2024	12/1/2024	6/1/2026	$57,205	$102,738	$20,548	$30,822	$51,369
		4	Closed	0.4	0.6	~1/15/2025	12/1/2025	6/1/2027	$53,408	$96,868	$19,374	$29,060	$48,434
		5	Closed	0.3	0.5	~1/15/2026	12/1/2026	6/1/2028	$49,864	$88,795	$17,759	$26,639	$44,398
		6	Closed	0.3	0.3	~1/15/2027	12/1/2027	6/1/2029	$46,554	$58,605	$11,721	$17,581	$29,302
		7	Closed	0.3	0.4	~1/15/2028	12/1/2028	6/1/2030	$43,465	$85,954	$17,191	$25,786	$42,977
									Total Tariff Budget	$525,146			

Source: Natalie Mims Frick, Berkeley Lab

Standard Offer Contract

- Participants use a standard contract to offer front-of-the meter DERs to avoid or defer identified utility distribution investments.
  - Contract is based on Technology Neutral Pro Forma contract — for example, SDG&E’s contract is here.
  - DERs can be dispatchable or non-dispatchable.
- Participants can submit partial or full offers, and the utility can combine offers together to create a solution. Offers include a $/kW-month price.
- The offer price cap is the value of a one-year deferral of the planned distribution project, which the utilities publish. Once 90% of the capacity is filled the utilities start the contract process.
- Utilities are required to select one project annually to test the pilot.

Southern California Edison Standard Offer Contract Pilot Project

Project Description	Tier	Location(s) of Need	Distribution Service Required	Operating Date	Max 10-year Capacity Need (MW)	Max 10-year Duration (hr)	Standard Offer Contract Pilot Project Ranking
New Circuit at Eisenhower	Tier 1	Crossley 33kV	Capacity	6/1/2024	2.9	6	1
New Circuit at El Casco Substation	Tier 1	Jonagold 12kV	Capacity	6/1/2024	0.4	2	2
New Circuit at Elizabeth Lake	Tier 1	Guitar 16kV Oboe 16kV Trumpet 16kV	Capacity (UCT) FLAG	6/1/2024	9.0	11	3

Source: Natalie Mims Frick, Berkeley Lab